Original scientific paper

UDK: 663.674

Probiotic viability, ß-carotene and mineral contents, color, physicochemical and sensory properties of ice cream prepared with carrot (*Daucus carota* L.) puree and *Bifidobacterium animalis* subsp. *lactis* BB-12

DOI: 10.15567/mljekarstvo.2025.0205

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Received: 29.03.2024. **Accepted:** 15.03.2025.

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Abstract

In this study, we aimed to increase the functional properties of ice cream by adding carrot puree (CP; 10, 20 and 30 %) and *Bifidobacterium animalis* subsp. *lactis* BB-12. As CP addition increased, the total dry matter, fat, protein, ash, overrun, melting rate, viscosity, and L^* and $H°$ values of the ice cream decreased; the first dripping time; the complete melting time; the K, Mg, Na, Fe, Cu and Mn contents; and the a^*, b^* and C^* values increased (p<0.01). The amount of ß-carotene (0.13-12.94 mg/100 g) in all ice cream samples increased significantly with increasing CP ratio (p<0.01). The color of the ice cream preserved during storage. The *Bifidobacterium* BB-12 count in the probiotic ice cream samples ranged from 7.80-8.09 log cfu/g. The addition of 10 % CP did not affect the number of probiotics, while the addition of 20 % or 30 % CP decreased the number of probiotics. However, the viability rate was the highest (98.65 %) in the PC3 sample. All the samples containing CP received sensory scores between 5 and 7 out of 9 points, and the samples containing 10 % CP were more appreciated by the panellists after the control samples. In conclusion, a new functional ice cream variety that preserves its probiotic properties for at least 120 days (> 10^7 cfu/g), has 10 % CP, has a natural orange color and flavor, is mineral-enriched, and can reduce the amount of sugar used can be developed.

Keywords: ice cream; carrot; *Bifidobacterium animalis* subsp. *lactis* BB-12; ß-carotene; mineral; functional food

Introduction

Today, consumers are more conscious about the relationship between food and health, which has led to the emergence of new products that are beneficial to human nutrition and health. Consumers tend to prefer functional foods, often made from compounds derived from natural sources and probiotics and prebiotics (Haghani et al., 2021). In the development of functional foods, especially milk and dairy products, they are more suitable and popular (Turgut and Çakmakçı, 2009; Granato et al., 2018; Karaman and Ozcan, 2021). Ice cream is a dairy product that is consumed for pleasure by children and young people around the world and is very suitable for diversification (Çakmakçı et al., 2016). The composition of ice cream is basically as follows: skim milk dry matter (such as protein, lactose and minerals), fat (animal and/or vegetable origin such as milk fat), sugar, stabilizer and emulsifier. Various fresh and dried fruits, dietary fibers, probiotics, prebiotics, sweeteners, flavoring agents and coloring agents can be included in the composition of ice cream for various purposes (Goff and Hartel, 2013). Although ice cream has high nutritional value and calories, it is not sufficient in terms of natural antioxidants, pigments, vitamins, minerals or dietary fiber (Goff and Hartel, 2013; Hassan and Barakat, 2018; Ateteallah et al., 2019; Akca and Akpinar, 2021; Haghani et al., 2021; Kowalczyk et al., 2021; Genovese et al., 2022). Therefore, new functional ice cream variety(s) should be developed, and different sources should be used to enrich compounds that are insufficient in ice cream. Carrot (*Daucus carota* L.), depending on its variety, is rich in carotenoids, flavonoids, anthocyanins, vitamins (B_1, B_2, B_6 and ß-carotene), minerals (such as calcium, potassium and phosphorus), polyacetylenes and dietary fiber (Hassan and Barakat, 2018; Ateteallah et al., 2019), carotenoids, xanthophylls, ß-carotene, α-carotene, lutein, ß-cryptoxanthin, lycopene and zeaxanthin (Søltoft et al., 2011; Ahmad et al., 2019). Due to its antioxidant, anti-inflammatory, plasma lipid regulatory, antitumour, eye health protection, epithelial tissue nourishing and restorative properties, carrot is an important food that has protective/health benefits against various cardiovascular and cancer diseases and has drawn increased amounts of attention due to its nutritional value (Søltoft et al., 2011; Ahmad et al., 2019).

Ice cream is a good carrier of probiotic bacteria in dairy products (Cruz et al., 2009; Tripathi and Giri, 2014). Probiotics are live microorganisms that provide beneficial effects on the health of the host by balancing the microbial flora of the intestinal tract (Matias et al., 2016). Foods containing probiotics should be consumed regularly, the number of probiotic microorganisms in the product should be at a certain level (> 10^6 cfu/g), and it was reported that it would be good to have a level of 10^9-10^{10} cfu/g in recent studies (Li et al., 2021). The most important group of probiotic microorganisms is lactic acid bacteria, and the most commonly used probiotics are *Bifidobacterium* and *Lactobacillus* species (Matias et al., 2016).

This study aimed to contribute to the increased consumption and/or widespread use of carrots, which are difficult to consume, because they are not consumed by children and/or because they are hard, by providing an alternative area for use in ice cream. In addition, *Bifidobacterium* BB-12 was tested in combination with carrots to improve the functional properties of the ice cream. Thus, this study aimed to create new flavors and natural orange colors in probiotic and nonprobiotic ice creams and to develop new functional ice cream with high nutritional value. The effects of the addition of CP on the viability of *Bifidobacterium* BB-12 and the quality of the ice cream were determined via analyses of the produced ice cream.

Materials and methods

Materials

Raw cow milk (chemical composition: pH 6.79, 0.14 % titration acidity (lactic acid), 13.06 % dry matter, 4.0 % milk fat, 3.39 % protein and 0.69 % ash) and cream (chemical composition: pH 6.32, 81.76 % dry matter and 75.0 % milk fat) were obtained from the Atatürk University Food and Livestock Application and Research Center, Pilot Factory of Dairy Products (Erzurum, Türkiye). The milk powders (chemical composition: pH 6.74, 0.10 % lactic acid, 96.91 % dry matter, 1.25 % fat and 36.0 % protein) were obtained from Pınar Dairy Product Industry, Inc. (İzmir, Türkiye). Sugars, saleps and emulsifiers were obtained from local markets (Erzurum, Türkiye). The probiotic strain of *Bifidobacterium animalis* subsp. *lactis* (BB-12) (Nu-trish BB-12) was obtained from Chr-Hansen (Istanbul, Türkiye). Fresh orange carrots (*Daucus carota* L.) were obtained from a local greengrocer in Erzurum (Türkiye).

Preparation of carrot puree (CP)

Fresh orange carrots were kept in hot water (96 °C) for 1-2 minutes (min) after sorting and washing to prevent possible contamination. Then, the carrots were pureed in a kitchen processor (at the highest speed setting). The resulting carrot puree was weighed into sterile containers at the rates specified in the mix recipe. The CP (chemical composition: pH 6.57, dry matter 10.13 %, protein 1.32 %, ash 0.53 %, ß-carotene 71.34 mg/100 g; color characteristics: L^* 49.07, a^* 26.47, b^* 35.82, $H°$ 53.80 and C^* 44.30; microbiological properties: yeast-mold <2 log cfu/g, coliform group bacteria <1 log cfu/g) was maintained at +4 °C.

Preparation of the probiotic culture

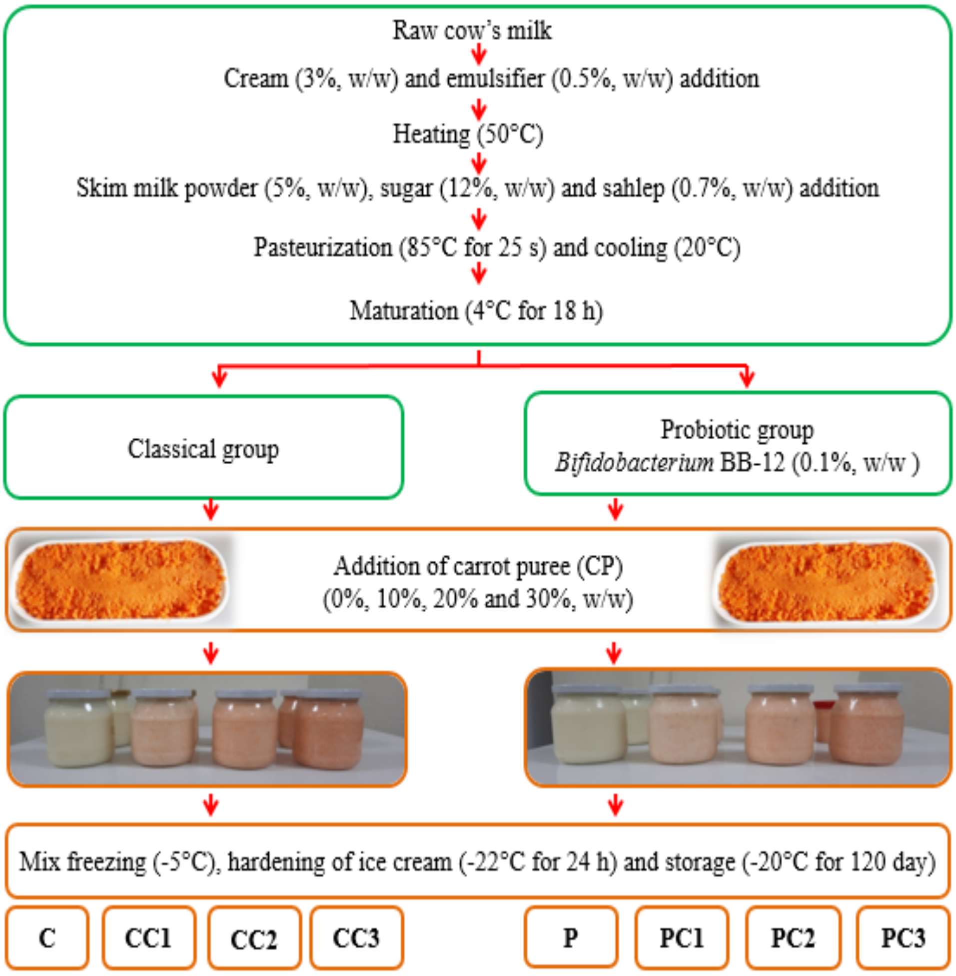
Ten percent of the milk reserved for the production of probiotic ice cream was transferred to 2 separate flasks in equal amounts and sterilized in an autoclave (10 min at 110 °C). Then, 0.1 % (w/v) lyophilized *Bifidobacterium* BB-12 was inoculated into milk cooled to 37 °C and incubated at 37 °C until a pH of 5.0 was reached. After the end of fermentation, incubation was completed at this value as pH would decrease during cooling in the fridge. In addition to the increased sensibility of probiotic microorganisms to low pH values (4.0–4.5), negative effects on sensory acceptance of the product may arise. These changes might be undesirable since ice creams are not generally characterized as highly acidic food products. The prepared cultures [containing 10^9 cfu (colony-forming units)/mL live probiotics with a pH of 4.7] were used in the production of ice cream (Cruz et al., 2009). The pH of probiotic-infused milk, just before ice cream production, is 4.7.

Production of the ice cream samples

The ice cream mix recipe was prepared in accordance with the composition of semiskimmed ice cream to contain at least 11 % nonfat milk solids and 5 % fat in the final product. Ice cream samples were produced in the Altın Patisserie (Erzurum, Türkiye) production department according to the flow chart given in Fig. 1. After the addition of CP and probiotic culture, the ice cream mixes were frozen in an ice cream machine (-5 °C; Telme Ecogel 40-120, İzmir, Türkiye) for 5-10 min and hardened at -22 °C for 24 hours. Subsequently, the samples were stored at -20 °C for 120 days. Ice cream samples were produced in duplicate, and analyses were carried out in 4 parallel experiments.

Physical and chemical analysis

In the CP treatment, the analyses of pH, dry matter, ash and protein (total nitrogen % × 6.25) were performed according to Cemeroğlu (2010). The amount of ß-carotene was determined by a spectrophotometric method with minor modifications by Olives Barba et al. (2006) and Butnariu (2016). Yeast and mold



C: control (without carrot puree (CP), CC1: 10 % CP added, CC2: 20 % CP added, CC3: 30 % CP added, P: probiotic control (probiotic bacteria added, without CP), PC1: probiotic bacteria and 10 % CP added, PC2: probiotic bacteria and 20 % CP added, PC3: probiotic bacteria and 30 % CP added

Figure 1. Production flow chart of ice cream samples

and coliform group bacteria counts were performed according to Beuchad et al. (2007) and Harrigan (1998), respectively. In the ice cream samples, the pH and dry matter, protein (total nitrogen % × 6.38) and ash contents were determined according to AOAC (2005); fat and titratable acidity were determined according to Kurt et al. (2012). Viscosity was measured in ice cream mixes as centipoise (cP) using a viscometer (Brookfield DV-II Model, Brookfield Engineering Laboratories, Stoughton, MA, USA) at 4 °C at 20 and 50 rpm using a spindle LV-4 (64) (Çakmakçı et al., 2016). The overrun rate was calculated according to the equation defined by Goff and Hartel (2013) using a standard 100 mL container [(weight of ice cream mix) - (weight of ice cream in same volume) ÷ (weight of ice cream in same volume) × 100]. First, for the dripping time, complete melting time and melting rate of ice cream samples, Cotrell et al. (1979) used a wire strainer (0.2 cm × 0.2 cm pore size) at room temperature.

β-carotene content analysis

The amount of ß-carotene in the ice cream samples was determined according to Olives Barba et al. (2006) and Butnariu (2016) with minor modifications. For this purpose, 2 g of ice cream sample was weighed into a centrifuge tube, and 18 mL of a hexane-acetone-ethanol (2:1:1; by volume) mixture was added. The samples were mixed in an orbital shaker at 250 rpm for 30 min in a dark environment. The mixture was subsequently centrifuged at 5000 rpm at +4 °C for 15 min and filtered through filter paper (Whatman No: 1). The absorbance of the sample extracts was measured at 450 nm in a spectrophotometer (Shimadzu UV-VIS 1800, Japan). For the preparation of the standard calibration curve ($y = 0.0390x + 0.0169$, $R^2 = 0.9991$), a ß-carotene standard (≥97 %, Sigma-Aldrich) prepared at different concentrations (1-30 mg/L) was used. The results are reported as mg/100 g.

Color measurements

The color properties of the ice cream samples were determined by using a colorimeter (Minolta CR-200, Minolta Chromometer, Japan) with the following parameters: L^* (100: white, 0: black), a^* (+: red, -: green), b^* (+: yellow, -: blue), H° (hue angle; 0°: red, 90°: yellow, 180°: green, 270°: blue, 360°: red) and C^* (color saturation) (Çakmakçı et al., 2016). The total color difference (ΔE) after freezing the mix and storing the samples was calculated according to Vukić et al. (2021).

Determination of probiotic viability

Ten grams of ice cream sample was weighed, and 90 mL of sterile physiological saline (0.85 % NaCl) was added to each sample. Then, a 10-fold dilution was made of the samples that were homogenized for 2 min in a Stomacher device (Interscience Bag Mixer® 400, France) until a dilution of 10^{-8} was reached. The *Bifidobacterium* BB-12 count in the probiotic samples was determined using MRS Agar (Merck) (3 days at 37 °C in an anaerobic jar) (Fritzen-Freire et al., 2013). The percentage of viable *Bifidobacterium* BB-12 was calculated using the formula [% viability = (cfu at 4 months of storage ÷ initial cfu) × 100] given by Shin et al. (2000). The number of coliform bacteria in the samples was determined using VRB agar (24 hours at 35-37 °C) (Harrigan, 1998) and the number of yeast-mold was determined using DRBC Agar (Merck) (3-5 days at 25 °C) (Beuchad et al., 2007).

Mineral analysis

The mineral compositions of the CP and ice cream samples were determined using a slightly modified version of the method proposed by Karaman et al. (2014). First, CP and ice cream samples were dried at 70 °C in a forced-air oven until dry weight. Then, 70 mg of each sample was weighed into Teflon cups, and 8 mL of nitric acid (HNO_3, 65 %, Merck) and 2 mL of hydrogen peroxide (H_2O_2, 30 %, Merck) were added to the samples. Then, the samples were digested in a microwave oven (Milestone, EthoS Easy) at 200 °C. The digested samples were diluted with ultrapure water to a final solution volume of 15 mL, and the solution was filtered (0.45 µm). Finally, the mineral matter contents of the samples were determined using an inductively coupled plasma mass spectrophotometer (ICP-MS-Agilent 7800, Agilent Technologies, Japan). The results are given in ppm (mg/kg dry weight) for the rmacrominerals and ppb (µg/kg dry weight) for the microminerals.

Sensory analysis

For the sensory evaluation of the ice cream samples, the color, texture, gummy structure, melting in mouth, flavor, sweetness and general acceptability criteria were scored as 1-9 (Bodyfelt et al., 1988). Ice cream samples (approximately 30 g) were stored at -10 °C after being placed in special transparent containers. The samples were evaluated on a score scale of 1 (poor/reject) to 9 (very good/ideal) by a group of 25 public panelists (nonsmokers, informed by us about the product and sensory analysis methods and with the same panel group as possible). Warm water was given to the panellists at the sample intervals to clean their mouths.

Statistical analysis

All the data were statistically analyzed using SPSS 20.0 (SPSS, Inc., Chicago, IL, USA), which is licensed software. The factors that were found to be important according to the variance (ANOVA) analysis were evaluated with the Duncan multiple comparison test at the 95 % confidence level. Pearson's correlation test was applied to the data to determine the relationships between the analysis parameters.

Results and discussion

Physical and chemical properties

The analysis results of the chemical properties and β-carotene contents of the ice cream samples are given in Table 1. The addition of CP did not affect the pH or titration acidity of the ice cream samples (p>0.05), but the combination of CP and *Bifidobacterium* BB-12 significantly affected these parameters (p<0.01). The titration acidity ranged from 0.11-0.32 %. The pH value of the carrot plant (6.57) is high and similar to the pH value of milk (6.79), which is the reason for this result in samples with only added CP. Since carrots are tuberous vegetables that are poor in organic acid and rich in fiber (Demir et al., 2007; Hassan and Barakat, 2018), they do not affect pH or acidity. In the probiotic group of ice cream samples, the pH decreased due to the increase in lactic acid as a result of lactose metabolism by *Bifidobacterium* BB-12 (Nguyen et al., 2012). As shown in Table 1, the lowest pH (5.75) was determined for the PC1 sample, and the highest pH (6.65-6.76) was determined for the classical group of ice cream samples (C-CC3). Karaman et al. (2014) determined the pH value to be 6.66-7.00 in ice cream samples containing persimmon (8-40 %) and Peasura et al. (2020) determined the pH value to be 6.80-7.00 in ice cream samples containing pumpkin puree (25-40 %).

The dry matter, fat, protein and ash contens of the ice creams varied between 25.53-30.88 %, 3.82-5.42 %, 3.19-3.96 % and 0.63-0.70 %, respectively. As the CP concentration increased, the dry matter, fat, protein and ash contents decreased (p<0.01). This is thought to occur because the dry matter content of CP (10.13 %) is lower than the dry matter content of milk (13.06 %), and CP constitutes a significant part of the total mix mass. Similarly, Karaman et al. (2014) determined that the amount of dry matter (28.02-32.51 %), fat (5.41-9.03 %), protein (2.63-4.66 %) and ash (0.78-1.08 %) decreased depending on the increase in the amount of persimmon added to the ice cream. On the other hand, Ateteallah et al. (2019) and Hassan and Barakat (2018) reported dry matter (36.36-43.61 %), fat (10.00-10.24 %) and ash (0.89-1.61 %) in ice cream with added carrot pulp. The amount of protein was similar to the value found by Hassan and Barakat (2018) (3.60-3.91 %), and the value found by Ateteallah et al. (2019) was lower than the amount found by (4.41-4.94 %). The differences between the studies are related to the preparation of ice creams according to the mixing recipes used and their different compositions.

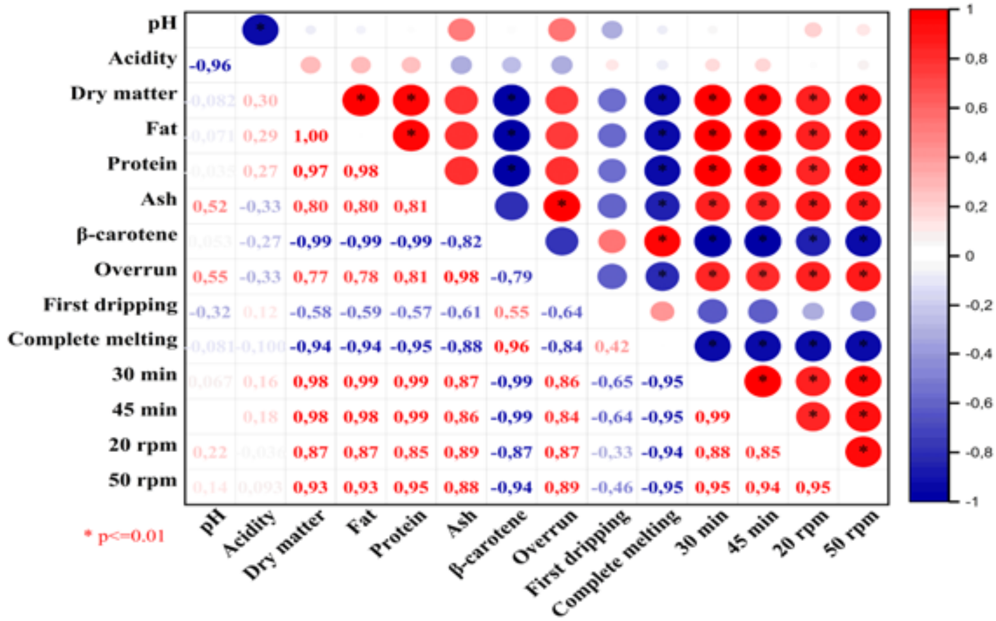
β-carotene, which is found in excess in orange carrots, is the most studied carotenoid due to its importance in medical science (Søltoft et al., 2011). The amount of β-carotene in milk is insufficient. Therefore, enriching dairy products with β-carotene will be beneficial for human nutrition (Çakmakçı et al., 2014). As shown in Table 1, the amount of β-carotene in the ice cream samples varied between 0.13 and 12.94 mg/100 g. As the CP ratio increased, the amount of β-carotene increased in all the samples (p<0.01). This result was due to the high amount of β-carotene in the carrot (71.34 mg/100 g). Similarly, Hassan and Barakat (2018) reported that the amount of total carotenoids in ice cream samples increased as the amount of carrot pulp increased. The addition of *Bifidobacterium* BB-12 relatively reduced the amount of β-carotene, except in the control (C and P) and 10 % CP-supplemented samples (CC1 and PC1) (Table 1). This difference may have resulted from the ice cream production process due to the metabolic activity or sensitivity of *Bifidobacterium* BB-12 to β-carotene (light, oxygen, etc.). On the other hand, Ateteallah et al. (2019) also detected the lowest amount of β-carotene in a control sample (12.42 mg/100 g) and the highest amount in a sample containing 15 % carrot pulp (2632 mg/100 g) in ice cream samples. In another study, as the pumpkin concentration increased, the amount of β-carotene (604.00-1207.30 μg/100 g) increased in ice cream samples (Peasura et al., 2020).

The analysis of Pearson's correlation coefficients between several physical and chemical properties of the ice cream samples is shown in Fig. 2. Accordingly, the amount of dry matter in the samples was positively correlated (p<0.01) with protein (r=0.97), fat (r=1.00), melting rate (r=0.98) and viscosity (20 rpm; r=0.87, 50 rpm; r=0.93), while the amount of dry matter was negatively correlated (p<0.01) with β-carotene (r=-0.99) and complete melting time (r=-0.94). The overrun value was positively correlated with the melting rate (30 min; r=0.86, 45 min: r=0.84) and viscosity (20 rpm; r=0.87, 50 rpm; r=0.89) (p<0.01).

Table 1. *Chemical properties and β-carotene contents of the ice cream samples*

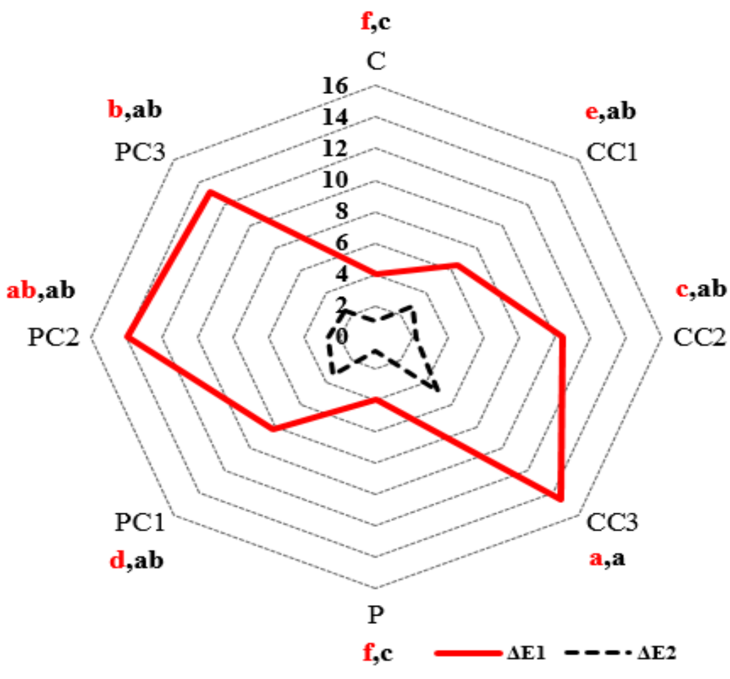
Samples	pH	Titration acidity (%)	Dry matter (%)	Fat (%)	Protein (%)	Ash (%)	β-carotene (mg/100 g)
C	6.76±0.09^{a}	0.15±0.04^{c}	30.79±0.21^{a}	5.47±0.48^{a}	3.96±0.24^{a}	0.70±0.04^{a}	0.19±0.06^{f}
CC1	6.65±0.10^{a}	0.14±0.05^{c}	29.03±0.36^{b}	4.93±0.18^{abc}	3.72±0.29^{a}	0.68±0.05^{b}	3.91±0.39^{e}
CC2	6.67±0.09^{a}	0.14±0.04^{c}	27.32±0.41^{c}	4.39±0.33^{cd}	3.36±0.24^{b}	0.66±0.05^{c}	9.32±0.66^{c}
CC3	6.73±0.12^{a}	0.11±0.03^{c}	25.53±0.33^{d}	3.82±0.32^{e}	3.19±0.12^{b}	0.65±0.03^{cd}	12.94±0.71^{a}
P	5.94±0.06^{b}	0.26±0.06^{ab}	30.88±0.38^{a}	5.42±0.41^{a}	3.90±0.19^{a}	0.68±0.05^{b}	0.13±0.06^{f}
PC1	5.75±0.11^{c}	0.32±0.05^{a}	29.18±0.31^{b}	4.96±0.23^{ab}	3.78±0.20^{a}	0.65±0.04^{cd}	3.98±0.35^{e}
PC2	5.85±0.12^{bc}	0.26±0.04^{ab}	27.78±0.32^{c}	4.52±0.47^{bc}	3.36±0.22^{b}	0.64±0.05^{de}	9.10±0.79^{d}
PC3	5.97±0.08^{b}	0.22±0.03^{b}	25.84±0.32^{d}	3.96±0.31^{de}	3.22±0.24^{b}	0.63±0.05^{e}	11.58±0.83^{b}

a-e: Means shown with different exponential letters in the same column (↓) are significantly different from each other (p<0.01)



*: p<0.01. The color scale bar indicates a positive (white to red) or negative (white to dark blue) correlation

Figure 2. Pearson's correlation coefficients between some physical and chemical properties of ice cream samples



Means shown with different exponential letters ($^{a-f}$) in the same color are significantly different from each other (p<0.01) (ΔE_1: total color difference in the ice cream during the freezing of the mix; ΔE_2: total color difference in ice cream at the end of storage)

Figure 3. Color difference in ice cream samples

The analysis results of the physical properties of the ice cream samples are given in Table 2. Overrun is directly related to the yield of ice cream and is an important quality parameter that also affects the structure, texture and flavor of the product (Goff and Hartel, 2013). The overrun rate of the ice cream samples varied between 25.23 and 41.23 %. As the CP level increased, the overrun value of the samples decreased (p<0.01). This result may be due to the low dry matter content of CP, which reduces the amount of dry matter, fat and protein in ice cream samples. Additionally, the decrease in viscosity may have decreased the degree of overrun (Table 2). Viscosity significantly affects overrun (Ateteallah et al., 2019). Similarly, Hassan and Barakat (2018) studied ice cream samples containing carrot pulp (41.88-44.10 %), and Haghani et al. (2021) reported that in ice cream samples containing cornelian cherry peel (47.46-56.56 %), the overrun value decreased as the pulp/fruit amount increased.

As shown in Table 2, the first dripping time of the ice cream samples ranged from 774-1240 seconds, and the complete melting time ranged from 4006-8298 seconds. The lowest melting rate (15.69-15.89 %) at the 30th min and the lowest melting rate at the 45th min (35.99-36.21 %) were determined for the samples containing 30 % CP (CC3 and PC3). The highest melting rate was found for sample C after 30 min (44.26 %) and 45 min (93.61 %). As the CP increased, the first dripping and complete melting times increased, and the melting rate decreased ($p<0.01$). In brief, the addition of carrot puree increased the resistance of the ice cream to melting at room temperature, allowing it to melt later. This difference may be because water-soluble or insoluble fibers in CP dissolve in water and bind some of the water or because ice creams affect the emulsion system. Previous studies have shown that there is a high amount of pectin in carrot pulp, and the addition of carrots increases the melting point and increases the melting resistance in ice cream samples (Atetallah et al., 2019); moreover, the addition of cornelian cherry peel decreases the melting rate in ice cream samples, and this effect is associated with the high amount of pectin in the structure of cornelian cherry (Haghani et al., 2021).

The viscosity of the samples at 20 rpm ranged from 8474-13987 cP, and the viscosity at 50 rpm ranged from 3781-6875 cP. As the amount of CP increased, the viscosity decreased

Table 2. Physical properties of the ice cream samples

Samples	Overrun (%)	First dripping time (s)	Complete melting time (s)	Melting rates (%)		Viscosity (cP)	
				30 min	45 min	20 rpm	50 rpm
C	41.2±2.5^{a}	774±8^{cd}	4006±6^{d}	44.3±3.5^{a}	93.6±1.2^{a}	13987±1206^{a}	6875±409^{a}
CC1	35.8±1.7^{b}	570±1^{d}	5752±1^{c}	36.0±2.0^{bc}	82.0±2.7^{b}	10074±529^{c}	5164±106^{c}
CC2	32.4±2.4^{cd}	703±0^{cd}	7947±3^{a}	24.3±1.8^{d}	52.9±1.6^{d}	9219±493de	4483±415^{d}
CC3	30.7±1.3^{d}	1079±1^{ab}	8298±2^{a}	15.7±2.4^{e}	36.0±2.4^{e}	8730±898^{e}	4276±241^{d}
P	35.1±1.7^{bc}	919±1^{bc}	4307±3^{d}	39.9±2.5^{ab}	91.2±2.1^{a}	12268±915^{b}	6255±559^{b}
PC1	31.5±1.0^{d}	767±2^{cd}	6637±7^{b}	33.7±6.0^{c}	75.9±2.8^{c}	9587±194^{cd}	5477±215^{c}
PC2	27.5±1.9^{e}	899±2^{bc}	7703±3^{a}	23.6±4.0^{d}	50.4±3.9^{d}	9166±406de	4211±605^{d}
PC3	25.2±2.7^{e}	1240±2^{a}	8071±5^{a}	15.9±2.3^{e}	36.2±1.0^{e}	8474±645^{e}	3781±445^{e}

$^{*a-e}$: Means shown with different exponential letters in the same column (↓) are significantly different from each other (p<0.01)

Table 3. Color properties of mix and ice cream samples

		n	*L**	*a**	*b**	*H°*	*C**
Mix samples	C	2	82.45±0.09^{b}	-3.68±0.01^{f}	8.88±0.02^{e}	112.50±0.17^{a}	9.58±0.04^{e}
	CC1	2	75.19±0.18^{e}	8.01±0.36^{e}	14.96±0.15^{c}	61.90±0.87^{d}	16.97±0.29^{c}
	CC2	2	72.43±0.16^{f}	13.16±0.13^{b}	19.67±0.25^{a}	56.27±0.55^{ef}	23.66±0.18^{a}
	CC3	2	70.01±0.05^{g}	14.28±0.04^{a}	19.92±0.61^{a}	54.40±0.79^{g}	24.50±0.51^{a}
	P	2	84.04±0.12^{a}	-3.24±0.03^{f}	10.30±0.02^{d}	107.53±0.06^{b}	10.80±0.02^{d}
	PC1	2	78.80±0.10^{c}	7.46±0.32^{e}	14.79±0.41^{c}	63.27±0.67^{c}	16.56±0.49^{c}
	PC2	2	75.85±0.52^{d}	10.46±0.64^{c}	16.21±0.60^{b}	57.23±0.60^{e}	19.29±0.85^{b}
	PC3	2	72.43±0.48^{f}	13.83±0.97^{ab}	20.12±0.68^{a}	55.57±1.01^{f}	24.41±1.11^{a}
Ice cream samples	C	18	86.08±1.56^{b}	-2.81±0.25^{g}	8.91±0.77^{e}	107.45±1.08^{a}	9.32±0.82^{e}
	CC1	18	80.30±0.97^{d}	4.40±1.22^{e}	21.29±1.56^{d}	78.36±3.20^{d}	21.85±1.55^{d}
	CC2	18	76.35±2.24^{f}	7.97±1.21^{c}	28.56±1.70^{c}	74.50±2.01^{e}	29.69±1.80^{c}
	CC3	18	72.83±1.37^{g}	11.39±1.45^{a}	31.48±1.68^{a}	70.22±1.70^{g}	33.49±1.99^{a}
	P	18	87.43±0.96^{a}	-2.54±0.14^{g}	8.83±0.48^{e}	106.11±0.71^{b}	9.11±0.45^{e}
	PC1	18	82.48±1.51^{c}	2.97±1.22^{f}	21.84±1.30^{d}	82.38±3.05^{c}	22.02±1.40^{d}
	PC2	18	79.36±1.37^{e}	6.40±1.18^{d}	30.38±1.54^{b}	78.18±2.02^{d}	31.03±1.62^{b}
	PC3	18	75.77±1.68^{f}	10.08±1.45^{b}	32.04±2.29^{a}	72.70±2.47^{f}	33.60±2.34^{a}
Storage period (day)	1	16	79.39±5.25^{a}	5.69±5.52^{a}	23.05±9.51^{a}	81.53±14.34^{a}	24.11±10.16^{a}
	15	16	79.81±5.32^{a}	4.83±5.17^{a}	22.44±9.17^{a}	83.43±14.12^{a}	23.31±9.67^{a}
	30	16	78.61±5.00^{a}	4.40±5.08^{a}	24.17±9.77^{a}	84.83±13.59^{a}	24.86±10.24^{a}
	45	16	80.18±4.39^{a}	4.24±5.04^{a}	23.61±9.60^{a}	85.17±13.92^{a}	24.34±9.95^{a}
	60	16	81.38±5.06^{a}	4.47±4.78^{a}	21.95±9.04^{a}	83.97±14.21^{a}	22.74±9.42^{a}
	75	16	79.97±5.30^{a}	4.36±5.14^{a}	22.04±8.60^{a}	84.30±14.37^{a}	22.80±9.04^{a}
	90	16	80.83±5.54^{a}	5.07±5.58^{a}	24.05±9.33^{a}	83.43±14.10^{a}	24.98±9.86^{a}
	105	16	79.73±4.50^{a}	4.96±5.36^{a}	22.63±8.97^{a}	83.02±14.36^{a}	23.63±9.47^{a}
	120	16	80.77±4.77^{a}	4.60±5.12^{a}	22.32±9.11^{a}	83.98±14.65^{a}	23.13±9.59^{a}

$^{**a-g}$: Means shown with different exponential letters in the same column (↓) are significantly different from each other (p<0.01)

in all the samples (p<0.01). This decrease was due to the low dry matter content of CP (10.13 %) and the significant proportion (10, 20 and 30 %) of the total mix mass. According to Çakmakçı et al. (2016), the viscosity of ice cream samples produced with the addition of kumquat varied between 5070-9382 cP at 20 rpm and 2799-5613 cP at 50 rpm, and the addition of 5-10 % kumquat reduced the viscosity. In another study, the viscosity decreased as the fruit ratio increased in ice cream samples enriched with persimmon (Karaman et al., 2014). In contrast, as the amount of cornelian cherry peel increased, the viscosity increased and changed in the range of 414.10-771.50 cP (Haghani et al., 2021).

Color properties

Color is very important in products such as ice cream and fruit yogurt, which are especially loved by children and young people (Çakmakçı et al., 2016). The analysis results of the color properties of the ice cream samples are given in Table 3. In the ice cream samples, the *L** values ranged from 72.83-87.43, the *a** values ranged from -2.81-11.39, the *b** values ranged from 8.83-32.04, *the H°* values ranged from 70.22-107.45, and the *C** values ranged from 9.11-33.60. As the amount of CP increased in the samples, the *L** and *H°* values decreased, and the *a**, *b** and *C** values increased (p<0.01). Similar results were reported by Karaman et al. (2014) for ice cream with persimmon and Peasura et al. (2020) for ice cream with pumpkin puree.

The *a**, *b** and *C** values determined in the ice cream samples with carrot puree were determined by Çakmakçı et al. (2016) and were found to be greater than the *a** (-2.02-(-2.56), *b** (13.68-17.88) and *C** (13.87-18.01) values determined in ice cream samples containing kumquat, and the *L** and *H°* values were found to be low (*L**: 83.12-85.64, *H°*: 94.78-100.75), which may be due to excessive use. The greater intensity of the color of the ice cream samples containing CP compared to that of the ice cream containing kumquat may be due to the darker color of the carrot and its high use. The *H°* values of the control group samples (C and P) are in the yellow-green region since they are between 90° and 180°. In the ice cream samples, as the CP amount increased, the *H°* value approached 0°, and the color became darker. This result was due to the presence of β-carotene, which is a characteristic color (*L**: 49.07, *a**: 26.47, *b**: 35.82, *H°*: 53.80 and *C**: 44.30) of orange carrot and constitutes a significant share of the total mix mass.

The calculated color difference values are shown in Fig. 3. The effect of freezing on the color properties of the mix was found to be statistically significant (*p*<0.01). The smallest difference (ΔE_1) was determined for the K (4.06) and P samples (3.92), while the largest color difference was found for the CC3 sample (14.59). As the CP increased, the color difference also increased (p<0.01). After the freezing process, the *L**, *b** (except for the P samples), *H°* (except for the C and P samples) and *C** (except for the C and P samples) values increased, while the *a** value (except for the C and P samples) decreased (Table 3). The difference in color (ΔE_2) caused by the frozen sample storage process was not significantly different between the C and P samples and the CC1, CC2, PC1, PC2 and PC3 samples (p>0.05). These findings revealed that the color properties of the carrot ice cream samples were preserved after 120 days of storage.

Table 4. Bifidobacterium BB-12 count and viability ratios in probiotic ice cream samples

		n	*Bifidobacterium* BB-12 (log cfu/g)	Viability ratio (%)
Mix samples	P	2	9.00±0.01^a	-
	PC1	2	8.92±0.09^a	-
	PC2	2	8.93±0.02^a	-
	PC3	2	8.93±0.02^a	-
Ice cream samples	P	18	8.09±0.11^a	96.65±1.04^b
	PC1	18	8.06±0.19^a	96.93±0.60^b
	PC2	18	7.91±0.23^b	96.32±0.91^b
	PC3	18	7.80±0.25^c	98.65±0.86^a
Storage period (day)	1	16	8.19±0.14^a	-
	15	16	8.17±0.11^a	-
	30	16	8.07±0.12^{ab}	-
	45	16	8.01±0.08^{bc}	-
	60	16	7.92±0.14^{cd}	-
	75	16	7.95±0.12^{bcd}	-
	90	16	7.55±0.33^e	-
	105	16	7.86±0.30^d	-
	120	16	7.95±0.25^{bcd}	-

$^{a-e}$: Means shown with different exponential letters in the same column (↓) are significantly different from each other (p<0.01)

Viability of probiotic bacteria and other microorganism during cold storage

Table 4 presents the changes in the probiotic counts of the ice cream samples during storage. The initial inoculum counts of *Bifidobacterium* BB-12 varied from 8.92 to 9.00 log cfu/g for the mix samples (p>0.05). The counts of *Bifidobacterium* BB-12 varied from 7.80 to 8.09 log cfu/g in the ice creams and from 7.55 to 8.19 log cfu/g during storage. The viability ratio varied from 96.32 to 98.65 % for the probiotic bacteria in the ice creams. The addition of 30 % CP increased cell viability (p<0.01) (Table 4). The *Bifidobacterium* BB-12 count decreased by 0.63-0.96 log cfu/g during the processing of the mixes into ice cream and by 0.11-0.30 log cfu/g during the storage of the ice cream. However, it was at the level recommended by Li et al. (2021) (≥10^7 cfu/g) for beneficial effects as a probiotic. This result, according to many researchers, can be explained by the fact that the oxygen in the air present during the processing of the mix to ice cream has a toxic effect on most anaerobic probiotics, and the ice crystals that form due to thermal shock can cause damage to bacterial cells (Tripathi and Giri, 2014; Haghani et al., 2021). Furthermore, cold stress on the bacteria during storage at -20 °C may have caused a decrease in the viable population (Cruz et al., 2009). Similarly, Haghani et al. (2021)

0.94-1.26 log cfu/g, and Kowalczyk et al. (2021) 0.39-0.46 log cfu/g reported a decrease. Similar findings were reported for the counts of *Bifidobacterium* BB-12 in probiotic ice cream samples produced with the addition of various furits, dietary fibers and other substances during storage (Akca and Akpinar, 2021; Haghani et al., 2021; Kowalczyk et al., 2021).

The microbial viability of the ice cream slowly decreased as the pH decreased and the acidity increased; however, all of the probiotic ice cream strains maintained counts of $\geq 10^7$ cfu/g during the 120 days. During storage, a gradual decrease in the probiotic population occurred, which was dependent on pH because the pH changed. Therefore, this decline may be due to the deceleration of the metabolic activity of bacteria due to prolonged storage. Ice creams that contain *Bifidobacterium* BB-12 should be developed and promoted by the food industry. During storage (days 1 and 120), coliform bacteria (<1 log cfu/g) and yeast-mold bacteria (<2 log cfu/g) were not found in any of the ice cream samples.

Mineral composition

Calcium is found in large amounts in milk and has an important role in regulating many basic functions in the body, such as muscle, nervous and immune systems (Nabrzyski et al., 2006; Gharibzahedi and Jafari, 2017). The macromineral (mg/kg dry weight) and micromineral (µg/kg dry weight) contents of the CP and ice cream samples are given in Table 5. The amount of Ca in the ice cream samples varied between 3065 and 3584 mg/kg dw ($p<0.01$). Hernández Toxqui et al. (2021) reported that the amount of Ca in ice cream enriched with tenebrio, chia and quinoa ranged from 2391-3320 mg/kg. Çakmakçı et al. (2016) studied ice cream with kumquat (4998-5780 mg/kg), and Haghani et al. (2021) reported that the addition of fruit reduced the Ca concentration in cornelian cherry ice cream (2019-2481 mg/kg).

Dairy products are also a good source of P (Nabrzyski, 2006). The amount of P in the ice cream samples varied between 2545 and 2973 mg/kg dw. Although 10 % and 20 % CP addition did not affect the amount of P in the ice cream ($p>0.05$), 30 % CP addition increased the amount of P ($p<0.01$). Similarly, Hernández Toxqui et al. (2021) reported that the amount of P in enriched ice cream samples varied between 1564 and 2245 mg/kg. In contrast, Haghani et al. (2021) determined that as the amount of fruit increased, the amount of P decreased (624-1019 mg/kg) in ice cream samples containing cornelian cherry peel.

The lowest K amount (4221 mg/kg dw) in the ice cream samples was detected in the P sample, and the highest K amount (6719 mg/kg dw) was detected in the CC3 sample. The addition of CP at increasing concentrations significantly increased the amount of K ($p<0.01$). This was due to the high content of K (18637 mg/kg) in CP. Similar findings were reported for ice cream samples containing kumquat (2956-4572 mg/kg) by Çakmakçı et al. (2016) and cornelian cherry peel (2321-3013 mg/kg) by Haghani et al. (2021). The amounts of Mg and Na in the ice cream samples varied between 225 and 336 mg/kg dw and between 1133 and 1815 mg/kg dw, respectively. Compared with those in the control group (C and P), the amounts of Mg and Na in the CP-treated samples increased. This was due to the high content of Mg (903 mg/kg) and Na (4702 mg/kg dw) in the CP. Similar findings were found

***Table 5.** Mineral compositions of the CP and ice cream samples*

Samples	Macro minerals (mg/kg dw)				
	Ca	P	K	Mg	Na
CP	2840±9	2013±97	18637±307	903±4	4702±71
C	3403±235^{a}	2774±276^{ab}	4469±95^{e}	243±54^{b}	1133±48^{d}
CC1	3408± 56^{a}	2726±38^{ab}	4991±135^{d}	272±19^{ab}	1248±24^{d}
CC2	3484±183^{a}	2804±63^{ab}	5468±98^{c}	294±19^{ab}	1464±94^{bc}
CC3	3584± 97^{a}	2973±132^{a}	6719±73^{a}	336±18^{a}	1815±23^{a}
P	3084±274^{a}	2563±30^{ab}	4221±58^{e}	225±24^{b}	1205±67^{d}
PC1	3198±146^{a}	2689±143^{ab}	5114±160	266±35^{ab}	1425±71^{c}
PC2	3137± 68^{a}	2572±161^{ab}	5191±131^{cd}	274±29^{ab}	1435±79^{c}
PC3	3065±422^{a}	2545±265^{b}	5824±257^{b}	300±30^{ab}	1613±20^{b}

Samples	Micro minerals (µg/kg dw)			
	Fe	Cu	Mn	Zn
CP	14531±368	3278±153	7914±188	14975±2733
C	4188±78^{d}	82±5^{f}	150±4^{g}	11254±136^{a}
CC1	5886±19^{c}	144±6^{e}	519±14^{f}	10336±108^{bc}
CC2	8132±175^{b}	379±30^{c}	981±38^{d}	11137±96^{a}
CC3	9485±202^{a}	619±24^{a}	1487±124^{b}	10671±555^{ab}
P	2993±160^{e}	171±11^{e}	267±32^{g}	10671±101^{d}
PC1	3716±235^{d}	226±10^{d}	775±103^{e}	8997±592^{d}
PC2	8791±344^{a}	348±44^{c}	1175±108^{c}	9706±82^{c}
PC3	9190±256^{a}	509±27^{b}	1927±64^{a}	8788±132^{d}

CP: Carrot puree, $^{*a-e}$: Means shown with different exponential letters in the same column (↓) are significantly different from each other (p<0.01) in ice cream samples containing kumquat (Mg; 495-539 mg/kg) by Çakmakçı et al. (2016) and cornelian cherry peel (Mg; 316-478 mg/kg) by Haghani et al. (2021). Hernández Toxqui et al. (2021) determined the amount of Na in enriched ice cream samples to be 1887-2328 mg/kg.

Mineral deficiency (especially of Fe, Zn and I) causes serious public health problems in many developing countries. Therefore, mineral-enriched foods are very important (FAO, 2001). Fe is an essential mineral that has many important functions in the body (hemoglobin and myoglobin production, electron transport, etc.) and is found in the structure of enzymes (Gharibzahedi and Jafari, 2017). The amounts of Fe, Cu and Mn in the microminerals in the ice cream samples ranged from 2993-9485 µg/kg dw, 82-619 µg/kg dw and 150-1927 µg/kg dw, respectively. Increasing CP addition increased the Fe, Cu and Mn contents of the ice cream ($p<0.01$). This result occurred because CP contains excessive amounts of Fe (14531 µg/kg dw), Cu (3278 µg/kg dw) and Mn (7914 µg/kg dw). The amount of Zn in the ice cream samples varied between 8788 and 11254 µg/kg dw, and the amount of Zn decreased with the addition of CP (Table 5).

Sensory properties

The scores of the sensory evaluations of the ice cream samples are given in Table 6. The control samples (C and P) had the highest scores for all the sensory properties. The color scores of the ice cream samples containing 30 % CP were greater than those of the samples containing 10 % and 20 % CP. As the CP concentration in the ice cream samples increased, the texture (5.7-7.2), gummy structure (5.2-7.0), melting in the mouth (5.1-6.3), flavor (5.7-7.1), sweetness (6.3-7.5) and general acceptability (5.8-7.2) scores decreased ($p<0.01$). Similarly, Karaman et al. (2014) reported that the addition of more than 24 % persimmon reduced overall acceptability in ice cream samples. In conclusion, the panelists gave all the samples containing CP a score of 5 to 7 out of 9 points, followed by the control samples, which were those containing 10 % CP at most (CC1 and PC1).

Conclusions

In this study, ice cream formulations with increased functional properties were developed by using carrots with a fibrous structure, a natural orange color, and high nutritional and health benefits together with *Bifidobacterium* BB-12 in the production of ice cream. The results showed that the addition of carrot puree (CP) and *Bifidobacterium* BB-12 significantly affected the quality of all the ice cream samples. The color properties of the ice creams remained stable during storage, and the addition of CP improved the color properties. The addition of CP increased the amounts of K, Mg, Na, Fe, Cu and Mn in the ice cream samples. The number of *Bifidobacterium* BB-12 colonies in the probiotic ice cream samples was determined to determine the desired therapeutic effect of the probiotic products (10^7-10^8 cfu/g) after 120 days of storage. All samples containing CPs were scored between 5 and 7 out of 9 points. Following the control samples, samples containing 10 % CP at most (CC1 and PC1)

Table 6. *Sensory properties of the ice cream samples*

		n	Color	Texture	Gummy structure	Melting in mouth	Flavor	Sweetness	General acceptability
Ice cream samples	C	225	8.4 ± 0.9^{a}	8.3 ± 0.9^{a}	8.1 ± 1.0^{a}	7.6 ± 0.7^{a}	8.1 ± 1.1^{a}	8.0 ± 1.1^{a}	8.2 ± 0.9^{a}
	CC1	225	7.1 ± 1.5^{bc}	7.2 ± 1.2^{b}	7.0 ± 1.3^{b}	6.3 ± 1.9^{b}	7.1 ± 1.39^{c}	7.5 ± 1.2^{b}	7.2 ± 1.3^{b}
	CC2	225	7.1 ± 1.3^{bc}	6.2 ± 1.3^{d}	5.8 ± 1.4^{d}	5.6 ± 1.8^{c}	6.5 ± 1.4^{d}	6.9 ± 1.3^{d}	6.5 ± 1.3^{d}
	CC3	225	7.2 ± 1.3^{b}	5.7 ± 1.5^{e}	5.2 ± 1.5^{e}	5.1 ± 1.8^{d}	5.7 ± 1.3^{f}	6.3 ± 1.3^{e}	5.8 ± 1.4^{e}
	P	225	8.3 ± 1.0^{a}	8.3 ± 1.3^{a}	8.8 ± 1.1^{a}	7.7 ± 0.8^{a}	7.8 ± 1.4^{b}	7.9 ± 1.1^{a}	8.1 ± 1.9^{a}
	PC1	225	6.9 ± 1.4^{c}	6.8 ± 1.3^{c}	6.8 ± 1.4^{c}	6.0 ± 1.9^{b}	6.6 ± 1.4^{d}	7.1 ± 1.2^{c}	6.8 ± 1.4^{c}
	PC2	225	7.0 ± 1.3^{bc}	6.2 ± 1.3^{d}	6.0 ± 1.2^{d}	5.4 ± 1.8^{cd}	6.2 ± 1.3^{e}	6.7 ± 1.3^{d}	6.3 ± 1.3^{d}
	PC3	225	7.1 ± 1.3^{bc}	5.8 ± 1.3^{e}	5.3 ± 1.4^{e}	5.1 ± 1.8^{d}	5.8 ± 1.4^{f}	6.3 ± 1.4^{e}	5.8 ± 1.3^{e}
Storage period (day)	1	200	7.5 ± 1.3^{a}	6.8 ± 1.5^{b}	6.5 ± 1.5^{bc}	6.0 ± 1.8^{cd}	6.5 ± 1.7^{b}	7.1 ± 1.3^{ab}	6.6 ± 1.6^{cd}
	30	200	7.4 ± 1.5^{a}	6.4 ± 1.6^{c}	6.2 ± 1.9^{c}	6.4 ± 1.8^{ab}	6.5 ± 1.4^{b}	6.8 ± 1.3^{bc}	6.7 ± 1.6^{cd}
	45	200	7.5 ± 1.2^{a}	7.1 ± 1.5^{a}	6.6 ± 1.6^{ab}	6.2 ± 1.9^{abc}	7.0 ± 1.5^{a}	7.2 ± 1.3^{a}	7.1 ± 1.6^{ab}
	60	200	7.5 ± 1.4^{a}	7.0 ± 1.5^{a}	7.0 ± 1.5^{a}	6.6 ± 1.7^{a}	7.0 ± 1.4^{a}	7.2 ± 1.3^{a}	7.2 ± 1.5^{a}
	75	200	7.5 ± 1.2^{a}	6.9 ± 1.6^{a}	6.9 ± 1.7^{a}	6.5 ± 1.8^{a}	6.8 ± 1.7^{ab}	7.2 ± 1.5^{a}	7.0 ± 1.6^{ab}
	90	200	7.4 ± 1.5^{a}	6.8 ± 1.6^{a}	6.5 ± 1.8^{bc}	5.7 ± 1.9^{d}	6.8 ± 1.5^{ab}	7.2 ± 1.3^{a}	6.8 ± 1.5^{bc}
	105	200	7.7 ± 1.1^{a}	7.0 ± 1.4^{a}	6.4 ± 1.7^{bc}	5.3 ± 2.0^{e}	6.9 ± 1.4^{a}	7.2 ± 1.4^{a}	7.0 ± 1.4^{ab}
	120	200	6.8 ± 1.6^{b}	6.5 ± 1.6^{bc}	6.2 ± 1.7^{c}	6.1 ± 1.8^{bcd}	6.2 ± 1.7^{c}	6.8 ± 1.5^{c}	6.4 ± 1.6^{d}

$^{*a-f}$*:Means shown with different exponential letters in the same column (↓) are significantly different from each other (p<0.01)* were preferred. If a more useful and darker orange color is desired, the use of CP at high rates (20 and 30 %) should be preferred. However, since carrots contain low amounts of dry matter, their high use in ice cream production dilutes the mix composition and weakens quality characteristics of ice cream. It is thought that it would be beneficial to include carrots in ice cream mixes with different food processing techniques (such as carrot juice concentrate and/or carrot powder) to increase both the quality and health benefits of ice cream. With new research, the sensory properties of carrot ice cream can be improved, and consumer appreciation can be increased. In conclusion, in this study, considering all the quality parameters, it was revealed that at least 10 % CP can be used for the production of functional ice cream. For these reasons, carrot can be used as a suitable natural additive in ice cream production to provide a new flavor, improve color and reduce the added sugar content.

Funding

Funding was provided by the Atatürk University Administration System of Scientific Research Projects (Project Number: BAP FYL-2021-8655), Erzurum, Türkiye.

Acknowledgments

The authors are grateful to the Atatürk University Administration System of Scientific Research Projects for supporting this research (Project Number: BAP FYL-2021-8655). Additionally, the authors would like to thank Altın Patisserie (Erzurum, Türkiye) for help in manufacturing the ice cream samples.

Probiotička održivost, sadržaj ß-karotena i mineralnih tvari, boja, fizikalno-kemijska i senzorska svojstva sladoleda pripremljenog s pireom od mrkve (*Daucus carota* L.) i *Bifidobacterium animalis* subsp. *lactis* BB-12

Sažetak

U ovom istraživanju željeli smo povećati funkcionalna svojstva sladoleda dodavanjem pirea od mrkve (CP; 10, 20 i 30 %) i *Bifidobacterium animalis* subsp. *lactis* BB-12. Kako se povećavao dodatak CP ukupna suha tvar, mast, proteini, pepeo, povećanje volumena, topljivost, viskoznost i *L** i *H*° vrijednosti sladoleda su se smanjivali; a vrijeme prvog kapanja; potpuno vrijeme otapanja; udjel K, Mg, Na, Fe, Cu i Mn te vrijednosti a*, b* i C* su porasle (p<0,01). S povećanjem CP udjela količina ß-karotena (0,13-12,94 mg/100 g) u svim uzorcima sladoleda značajno se povećavala (p<0,01). Boja sladoleda je očuvana tijekom skladištenja. Broj *Bifidobacterium* BB-12 u uzorcima probiotičkog sladoleda kretao se od 7,80-8,09 log cfu/g. Dodatak 10 % CP nije utjecao na broj probiotika, dok je dodatak 20 % ili 30 % CP smanjio broj probiotika. Međutim, preživljavanje bakterija bilo je najveće (98,65 %) u PC3 uzorku. Svi uzorci s CP dobili su senzorske ocjene između 5 i 7 od 9 bodova, a uzorci s 10 % CP bili su bolje ocijenjeni od strane panelista, odmah nakon kontrolnih uzoraka. Istraživanjem je zaključeno da postoji potencijal razvoja novog funkcionalnog sladoleda koji zadržava svoja probiotička svojstva najmanje 120 dana (>10^7 cfu/g), ima 10 % CP, prirodnu narančastu boju i okus, obogaćen je mineralnim tvarima te ima smanjenu količinu šećera.

Ključne riječi: sladoled; mrkva; *Bifidobacterium animalis* subsp. *lactis* BB-12; ß-karoten; minerali; funkcionalna hrana

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